Curtain Airbag (CAB) performance analysis using Finite Element Analysis

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Abstract: A side impact of an automobile poses a higher risk of damage compared to those of a frontal impact. Therefore governments establish and implements new safety standards to ensure the safety of the occupants throughout the world called FMVSS 226. Federal Motor Vehicle Safety Standard (FMVSS) 226 Ejection Mitigation, was introduced to reduce the incidence of complete and limited ejections of vehicle passengers during accidents, especially in rollover cases. In FMVSS 226 there is a need for component-level tests of curtain airbag (CAB). A guided, linear impactor (Head form) is used into a rollover-activated countermeasure at up to different locations for each side window in the vehicle. As per the requirements of this regulation, the head form cannot travel more than 100 mm past the inside surface of the side window plane. In the current study, a detailed Finite Element Model (FEM) was developed on the CAB. Head form was used in the center location of the rear. Different design iterations were performed to optimize the CAB performance.

Index Terms: FEA, Hypermesh, LS-Dyna, Crashworthiness, Curtain Airbag.

I. INTRODUCTION

Due to less space to absorb energy during the side-impact, there is a high death rate as compared to the front impact during a vehicle crash. The government agencies of the whole world, as well as private sectors, are using various safety standards to protect the occupant from the side collision.

The common aim of those safety standards and NCAP (New Car Assessment Program) standards is to save the occupant from any type of fatal injury. To prevent head injury during the frontal impact the vehicle is designed to absorb the maximum energy by deforming to protect the occupant however during the side impact we cannot use this is structural advantage. To avoid injury in this consequences curtain Airbags are widely used to save the occupant. There is a benefit of installing the curtain airbag like they are easy to install and have very short deflation time. Engineers have to consider many nonlinear parameters while designing the airbag. The criteria of this parameter may be head injury, a variety of possible collision situations, etc. there are various researchers conducted in the past for the curtain airbag system. Like designing of an airbag system and also the kind of inflator needed to improve the curtain airbag inflation speed and to reduce the head injury criterion by Zhang and his colleagues. [1] Sensitivity analysis on design parameters such as the thorax/pelvis airbag systems and the thickness of car door structures, to reduce the occupant's injuries in a side collision. By Foneseka and his colleagues performed [2] The injury patterns of dummies and their dependence on airbag design parameters by Jeon and his team researched [3] uses of elements that have an influence on airbag inflation as the design parameters and applied them to achieve an optimum airbag design to minimize occupants’ injuries by Marklund and his colleagues [4-6] some researches are focuses on chest and abdomen related injury parameters, such as chest compression are the most important factors to body injuries during side collision

In current scenario the performance of airbag was considered as satisfactory if head impact does not exceed up to a certain fixed criteria However, In the airbag design stage we have to more focuses on head injury criteria because of the newly amended United States New Car Assessment Program (U.S. NCAP) regards the level of the head injury criterion as an important factor in the assessment. [9] It clearly indicates that head injuries are the most important factors on the injury distribution chart in case of death during a fatal injury in accident. In Case of serious injuries during an accident chest and back injuries are the influential factors on the injury distribution chart. By reference of previous studies, several parameters can directly impact the extent of injury these are Mass Flow Rate (MFR), Time to Fire (TTF), Vent Hole Area (VHA), Material Density (MD), Tether Length (TL). [10-13] especially one study performed sensitivity analysis on these design parameters and identified MFR, TTF, and VHA as the most important design parameters. [13] Engineers can obtain non-continuous design values instead of continuous design values using the Orthogonal Array (OA) which are difficult to use in real manufacturing the stage just like an optimum design. [15-16] Moreover using orthogonal arrays in a discrete space can help analyst to obtain required results within a limited iterations trials because they can use fractional replication for the combination of design parameters. [12] One way table is one of the simplest strategy. This test table can be used when only one factor is used while multiple levels are used. [14] This table is most widely used when the rest of the influential factors, that influence the characteristics values are examined. Only one influential factor remains to be examined for its influence under a given condition, if the number of levels is between 3 to 5 The one-way table is most commonly used , and the number of repetition is between 3 to 10.[17] Setting the number of levels to 3 and ±20% is done because of the level of design parameters can be selected appropriately according to a given condition. Also, normal design changes are limited and the design parameter values are chosen from several values. In statistics, the response surface methodology (RSM) explores the relationships between several explanatory variables and one or more response variables. The method was introduced by Box and Wilson in 1951, and has been studied by many other researchers recently. [17] This method is mainly used to optimize the approximation function.
In the case of analysis of occupant’s injuries, the response surface methodology can be a great tool to estimate HIC, an objective function, more effectively and easily. [12] In this research we had used PIAnO (Process Integration Automation and Optimization), (18) a commercially-sold statistical application, for Optimization was used.

II. METHOD
At first the baseline design of CAB we prepared using an existing patented CAB model. The baseline geometry of CAB is shown in figure 1 below. Overall length and height was considered as 1600 and 400 mm respectively.

*AIRBAG_SIMPLE_AIRBAG_MODEL_ID card was used to inflate the CAB cushion. MAT 34 fabrics available in LS_DYNA was used to model fabric behavior. Table 1 shows the fabric properties used in the current study.
Table 1: Fabric material properties

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Design iteration 1 was developed by shifting the stitching pattern rearward side as shown in figure 4.

Design iteration 2 was developed by increasing the coverage area of the CAB towards bottom side of the vehicle as shown in the figure 5. The height of the design iteration 2 was measured as 600 mm.

Each design iteration was tested in two different head form locations namely front and rear windows location. Figure 6 shows the rear window location of head form.
III. RESULTS

Figure 8 shows the inflated CAB of baseline design. Successive simulation steps are given in the figure below. It can be seen clearly that CAB cushion is not covering the impact surface of the vehicle i.e. side windows completely.
Figure 9 shows the inflated CAB of design iteration 1. Successive simulation steps are given in the figure below. It can be seen clearly that CAB cushion is not covering the impact surface of the vehicle i.e. side windows completely.

Figure 9: Deployment of design iteration 1

Figure 10 shows the inflated CAB of design iteration 2. Successive simulation steps are given in the figure below. It can be seen that CAB cushion is capable of covering the impact surface of the vehicle i.e. side windows completely.
As per requirements of this regulation, the head form cannot travel more than 100 mm past the inside surface of the side window plane. Figure 11 shows the maximum travel of the head form outside of the vehicle from the window glass surface.

Figure 11: Maximum headform displacement outside from the vehicle of design iteration 2
IV. CONCLUSIONS

Initially 2D of the baseline CAB was used to develop CAE model. Detailed CAB model was developed and optimized successfully. Final design was capable of holding the head form within the given limit.

REFERENCES